**9th Session of the JCOMM Observations Coordination Group**

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**Report Title: IOCCP coordination of activities relevant across JCOMM OCG elements**

**Authors: Maciej Telszewski, Artur Palacz, Masao Ishii, Kim Currie**

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**1. SUMMARY**

In this report we provide an overview of coordination activities relevant for several elements of JCOMM OCG in which IOCCP/GOOS Biogeochemistry Panel plays a significant or leading role. All of the described activities would benefit from input and discussion amongst interested representatives. Timeline for implementation varies and often extends the annual reporting period, therefore progress reporting with specific relevance for individual elements of JCOMM OCG (networks, task teams, other) is envisaged on annual basis.

**2. REPORT CONTENT**

**IOCCP plans to clarify and assemble a set of societal and scientific requirements and develop and implement observing and data management strategies for 3 biogeochemical EOVs.**

Currently, IOCCP maintains a set of specifications, implementation goals and progress metrics for 2 marine biogeochemical Essential Ocean Variables (BGC EOVs): Inorganic Carbon and Nutrients. To allow the local, regional and global communities to meet their observational needs and to enable understanding and quantification of the following phenomena: ocean acidification; ocean deoxygenation; eutrophication; exchanges between the atmosphere, surface ocean and deep ocean; and carbon and nutrient remineralization and sequestration, IOCCP aims to develop and implement observing strategies for 3 additional BGC EOVs.

By using its experience gained during coordination efforts for the inorganic carbon and nutrients communities and by forming effective partnerships with relevant interested players IOCCP hopes to start providing similar coordination services to Oxygen, Nitrous Oxide and Dissolved Organic Carbon communities. Ultimately we would like to enable the design of a feasible and fit-for-purpose observing system for each of these EOVs. Such a system would be based on scientific and societal needs as well as technical capacities available through OCG observing networks.

Specific activity: Over the 3-year period design, prepare, run and report from 3 dedicated technical workshops each focused on 1 EOV.

Relevant for JCOMM OCG elements: Observing networks capable of measuring specific EOV, Best Practices team

**Coordinate the Surface Ocean CO2 Observing NETwork (SOCONET)**

Establishment of SOCONET responds to the need to provide the high-quality data to constrain global and regional air-sea CO2 fluxes on seasonal timescales, to determine trends and patterns in surface water CO2 levels, and to elucidate the factors influencing the patterns on daily to decadal time scales and to provide important element of an OA monitoring system.

The idea of coordinating surface water CO2 observations has had a long history with incremental implementation of certain aspects of the network such as data collation and distribution (SOCAT and LDEO) or development of globally accepted standards and best practices for measurements and their metadata. However, there are still numerous aspects like quality of measurements themselves, collaboration with ship operators, design of the observing network globally, collaboration with other observing networks and more, which can only be improved or achieved globally through a coordinated structure.

As most of the global efforts in this field have been facilitated under aegis of IOCCP, the network was decided to be formed under auspices of IOCCP through a global partnership of investigators involved in ongoing efforts, both on ships of opportunity (SOOP-CO2) and fixed-platforms (mooring-CO2). To this end, IOCCP and US NOAA held the kick-off meeting of SOCONET on February 11, 2018, just prior to the Ocean Sciences Meeting in Portland, OR, USA. The meeting was attended by invited participants who represented the largest operators of surface water CO2 operations and/or activities relevant for network development.

The participants of the kick-off meeting decided that specific targets and metrics need to be developed to assess the efficacy of the network and its performance. The network participants will develop such network-wide set of targets and metrics, which will aid in network’s management and coordination. These targets and metrics will lead to deliverables that, to the extent possible, will mimic other successful networks like Argo or GO-SHIP. They will include: real-time transmission and dissemination of all data in the network, real-time tracking of assets, delayed mode quality controlled data including uncertainty estimates, and biannual releases of all data in the network in the form of collated data and maps. Participants of the network will confer at regular basis to discuss data products and publications resulting from the data obtained in the network.

The data-based products from the network will be used for scientific analyses, development of indicators of the variability in ocean ecosystems, and allowing biogeochemical and socio-economic assessments. In particular, the products will be critical for determining the effects of ocean acidification on marine ecosystem health, and quantification of anthropogenic carbon uptake on variety of scales. Therefore, the successful development of SOCONET as a sustained global ocean observing network should be considered critical to execute IOC’s and WMO’s mandates in climate and marine ecosystem health. More details on this activity is provided under agenda item *4.2.4 Surface CO2 Reference Network.*

**IOCCP plans to help develop a strategy for ship-based measurements of atmospheric CO2 allowing to meet the rigorous accuracy requirements set by the atmospheric community required to constrain the global carbon cycle estimates in Earth system models.**

Today, there are over 100 sites where atmospheric community scientists make high accuracy measurements of atmospheric CO2 (AtmCO2), and yet ocean regions remain severely under-sampled. Many of these ocean regions are regularly visited by research vessels and commercial ships with systems that measure CO2 in the surface seawater and in the overlying atmosphere. The atmospheric CO2 data from these ocean community CO2 systems (SeaCO2) does not typically meet the rigorous accuracy standards of the atmospheric community, as set out in the World Meteorological Organization recommendations.

Validating and improving the quality of SeaCO2 data will provide mutual benefits to both the oceanic and atmospheric communities and even more importantly, will allow better constrain of the global carbon cycle in Earth System models used for climate and ecosystem assessments (IPCC, IPBES). For example, accurate SeaCO2 data from ocean regions can be used by atmospheric scientists to constrain atmosphere-land CO2 fluxes. And accurate SeaCO2 data can be used by ocean scientists to calculate air-sea CO2 fluxes with higher accuracy, rather than relying on interpolated atmospheric CO2 data products, which can lead to significant biases.

IOCCP in collaboration with WMO’s Global Atmosphere Watch (GAW) and WMO/IAEA’a Greenhouse Gases and Measurement Techniques (GGMT) group will provide support to the surface ocean carbon observational community centred around the SOCONET network in order to develop dedicated instrument and gas handling protocols allowing to achieve sufficiently accurate SeaCO2 data using existing measurement systems. Also, as a joint atmospheric-oceanic community effort, we hope to provide a set of standard operating procedures that summarise best practice in shipboard atmospheric CO2 measurements. This joint-community resource, combined with additional collaboration between the atmospheric and oceanic communities, should lead to more high-accuracy SeaCO2 data over the coming decades.

Specific activity: Technical workshop on atmospheric measurements from ships, 20-25 participants

Relevant for JCOMM OCG elements: Best Practices team, SOCONET

**IOCCP will continue to develop and promote the use of standards, reference materials, manuals, best practices, etc. among the marine biogeochemistry observationalist community**

As part of a wider international effort IOCCP plans to increase it’s activity around standards and best practices development and dissemination.

The complexity of ocean observation systems is rapidly increasing as our ever-greater technical capacities for simultaneous biological, physical, and chemical observations allow us to inform new societal and economic requirements. Thus, our ability to exchange best practices has become more challenging as traditional mentoring proves less sustainable at scale.

To preserve their value, best practices need to be reliably archived, accessible, searchable, and comparable within and across disciplines as well as metrics such as EOVs or platforms/networks such as ships/SOCONET, floats/Biogeochemical Argo or autonomous vehicles. Advancing technologies need to be leveraged to enhance persistent, international repositories of ocean best practices where key documents of the global observing communities can be easily identified. Effective knowledge transfer should be ensured through community building including peer review, training and consultation with creators and users. Future use of autonomous, intelligent technologies for observations and linking information to users will further drive the need for best practices.

JCOMM OCG is at the centre of this wide community effort and a dedicated agenda item: *8. Standards and Best Practice* will provide more details on the current status and planned activities. IOCCP will enhance its efforts to systematize best practices in biogeochemistry by bridging human and machine knowledge and by strengthening partnerships with projects, programs and organizations focused on this fundamental element of the observing cycle.

IOCCP plans to continue the development of the Global Data Assembly Centre for Marine Biogeochemistry and Automation and FAIR implementation across platforms and biogeochemical EOVs.

Many central elements of the proposed Global Data Assembly Center for Marine Biogeochemistry (BGC GDAC) as proposed by the IOCCP in 2016 (http://www.ioccp.org/images/08dataANDinfo/IOCCP\_position\_paper\_on\_data\_management\_FINAL.pdf) are currently being simultaneously developed in Europe by the European Research Infrastructure Integrated Carbon Observation System (ERI ICOS) and in the USA by NOAA groups in it’s Pacific Marine Environmental Laboratory (NOAA PMEL) in collaboration with University of Washington. Some proposed elements are currently not funded and full implementation depends on consolidation of resources for the benefit of the interested communities. Standardised metadata forms are being developed and work progresses to make processing and quality control of underway Inorganic Carbon data fully operational. These efforts benefit from IOCCP’s central role as a coordination hub providing communication platform and support.

However, as ocean observing systems evolve, and an increasing number of autonomous platforms and sensors are deployed, the volume of data increases dramatically. Therefore, in order to better serve forecast and prediction communities, more efficient turnaround of quality data in known formats and made available through web services is required to provide open access to the data and the creation of relevant data products. In particular, data automation workflows will be critical to reduce data friction throughout the whole data lifecycle. This increased efficiency is relevant for all data types in marine biogeochemical observations even if currently some EOV data is not routinely ingested by any end-users.

Again, JCOMM OCG plays a central role in these efforts and a dedicated agenda item on this subject: *9 Data Management* will provide update on progress throughout disciplines and parameters.

IOCCP will continue to support data management community in our discipline in order to fully realize the vision drawn in our position paper in 2016. This process includes automation of level 1 and level 2 quality control procedures. When properly implemented, a universal benefit of such automated systems is the reduction of data management burdens to science projects, making it easier for the PI’s to provide data in standard formats, ensure the data are fully documented, provide interoperable data access through appropriate web services and in turn ease the integration of the data with the WMO Information System (WIS). The process will also ensure that data complies with the Findable, Accessible, Interoperable and Re-usable (FAIR) data guiding principles, which are a community-driven effort to improve the infrastructure supporting the reuse of scientific data. Currently negotiations with the GO-FAIR initiative (https://www.go-fair.org) are ongoing to highlight the steps already taken within the global marine biogeochemistry community, and to develop a showcase illustrating how FAIRness can directly support international bodies like IOC-UNESCO IODE in achieving their obligations towards the Sustainable Development Goals (SDGs) set by the United Nations (e.g. SDG 14.3. ‘minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels’).

While acknowledging the complexity of such a system, it seems that leveraging standard formats, conventions and existing tools makes it possible to build such systems in data management environments with reduced resources.

**IOCCP will continue to support the existing data synthesis products: SOCAT and GLODAP and lead the development on new data synthesis products based on community needs in particular ocean acidification and time series communities.**

The SOCAT community agreed to include additional surface parameters like nutrients, DIC and total alkalinity in SOCAT without quality control and release them in a separate file. This might start for version 7 (2019). There are ongoing discussions regarding the inclusion of surface ocean CH4 and N2O in SOCAT or as a parallel data product using SOCAT infrastructure. Additional issue currently considered concerns the inclusion of surface ocean fCO2 calculated from other parameters most often based on sensor technology installed on floats and gliders. This issue will be taken further by the SOCAT and relevant IOCCP groups with the initial focus on the quality assessment of such data. After many years of development, all SOCAT data are being submitted through the Upload Dashboard. Despite several advantages of this solution, some challenges still exist and will be resolved over the coming years. Also despite significant progress of the automation of the SOCAT metadata upload several issues still remain in development phase. The aim of the automation is to automate quality control of the metadata, in order to improve the metadata quality and to reduce the annual quality control burden on individual PIs. The objective is to have the automated metadata upload in place for SOCAT version 8 (2020).

GLODAP is the interior ocean data synthesis project supported by IOCCP and an important GOOS data product reporting on a range of Essential Ocean Variables, as well as additional interior ocean variables. The GLODAP Reference Group (which includes a number of IOCCP members) will ensure the continuous provision of updated interior ocean biogeochemical synthesis products based on data from ship based surveys. It will do this by adding data to GLODAPv2, after subjecting them to primary and secondary quality control. After completion of each round of the global repeat hydrographic survey (current round scheduled for completion in 2023), this group will be responsible for instigating a new full version of GLODAP (the next one will be version 3), which will entail a full re-evaluation of the entire product. Before then, cruises will be assessed for bias with respect to GLODAPv2 and the intermediate products released will be named GLODAPv2.YYYY where YYYY is year of release.

Development of a new, global, time-series based data synthesis product will be one of IOCCP’s foci over the coming years. This activity promises to attract interest from most time series sites and therefore has a large potential to serve as an axis for coordination. Such a product would have to serve a (set of) specific science goal(s), that in turn would have to be within scientific interest of participating sites. The ability to observe long term variability in physical, biogeochemical and biological phenomena and short to long term interconnectivity between the processes governing this variability, puts time series in a unique position within the global ocean observing system and makes the potential synthesis product(s) an extremely valuable perspective. During discussions with several time-series operators and funders, ocean acidification emerged as one critical phenomenon lacking data-based global synthesis product.

Creating coherent data synthesis products in the big data world becomes challenging due to pattern overload stemming from our ability to observe with ever-increasing frequency and coverage. In the age of big data from satellite missions, in situ campaigns, Earth System model simulations and high resolution reanalysis products, techniques such as machine learning, pattern recognition, data mining and similarly advanced statistical methods are becoming widely used. While their utility has been demonstrated in other areas of Earth Science, it is now also becoming apparent in marine biogeochemistry and other oceanographic disciplines. IOCCP plans to partner with most developed groups involved in “intelligent” mapping and create an active Exchange Forum aiming to assess the progress made to date, present current needs and opportunities for use of these techniques to create data synthesis products, foster collaboration and organize the community around new data synthesis efforts.

Specific activity: A 2 days SOCAT metadata Automation Team technical workshop, 10-15 participants

Relevant for JCOMM OCG elements: Data Management team, Best Practices team, SOCONET

Specific activity: A 2 days GLODAP technical workshop on data quality control, 10-15 participants

Relevant for JCOMM OCG elements: Data Management team, Best Practices team, GO-SHIP

Specific activity: To organize a workshop for main ship-based and moored time series observatories around the globe (10-15 participants) with the goal of scoping the work towards time series data synthesis products.

Relevant for JCOMM OCG elements: Data Management team, Best Practices team, OceanSITES